The HIGH SCHOOL JOURNAL

Vol. XL × **February, 1957** × **No. 5**

IN THIS ISSUE

High-School Science and Manpower Needs.... *John R. Mayor* 178

A Classroom Teachers Looks at Science-Teaching Objectives
Mary Polk Roberts 183

Opportunities in Science for Bright Pupils.... *Walter S. Lapp* 187

Non-Test Evaluations of the Outcome of Science Teaching
John G. Read 193

Helping Students Develop Scientific Methods
John B. Chase, Jr. 200

Journal Features
Audio-Visual Materials..... 207

THE CONTENTS OF THE HIGH SCHOOL JOURNAL ARE LISTED IN "EDUCATION INDEX"

Issued Monthly, October to May, Inclusive **$2.00 a Year**

Published by the University of North Carolina Press for the School of Education of the University of North Carolina.

SAMUEL M. HOLTON, *Editor*

Editorial Office: Box 810, Chapel Hill, N. C.

Business Office: Box 510, Chapel Hill, N. C.

High-School Science and Manpower Needs

JOHN R. MAYOR
American Association for the Advancement of Science

THE SHORTAGE

AN IMPORTANT fact of national life in this decade is that the shortage of educated, skilled manpower exists in all areas requiring special talent and training. It seems certain that the demand will increase for many years, and the shortage will become more critical. Greatest publicity has been given to the shortage of well-qualified persons in science and for teaching. The lack of persons scientifically and mathematically qualified for positions in this country in industry, government, and teaching at the college and pre-college levels, combined with information from the Soviet Union about the numbers of students being trained there for science and engineering, have brought about considerable alarm.

The Interim Report of the Subcommittee on Research and Development of the Congressional Committee on Atomic Energy has accurately stated the most important causal factor in pointing out:

> "It is important to recognize at the outset that these serious shortages are not a sign of failure but an indication of startling success. A way of life has been created in which the demands made for superior skills in every field have become so tremendous that growth and expansion have become constant elements of the normal pattern. A society has been created in which progress is not simply a matter of occasional spurts and short-term crises. Rapid progress has become a normal part of our national life, and the skilled manpower to keep up with this steadily and rapidly advancing march of progress will be in demand for years to come."

The shortage of well-qualified science and mathematics teachers cannot help but affect unfavorably the rate of production of future scientists and the quality of their training. Many students develop their interest in scientific careers at the high-school level. Also adversely affected will be the scientific knowledge and appreciation of the role of science on the part of the general public; many students are formally introduced to the sciences during their high-school years, and for a large number, high-school courses represent their only formal study of science. The shortage of teachers of science and mathematics poses serious consequences for scientific and technologic progress in the United States.

Statistics on enrollments in science and mathematics have been widely quoted. Many of these statistics imply that the percentage of students in secondary school enrolled in science and mathematics has sharply decreased during the past 25 years. Because of the misunderstanding of statistics quoted, the U. S. Office of Education recently published a pamphlet entitled, "Offerings and Enrollments in Science and Mathematics in Public High Schools." In graphic form the data presented in this pamphlet include such conclusions as the following: 10.9 per cent of 12th-grade students in American high schools in 1954 were enrolled in schools offering no trigonometry, solid geometry, or intermediate algebra; 6.8 per cent of 10th-grade pupils in 1954 were enrolled in schools not offering plane geometry; 5.8 per cent of 12th-grade pupils were enrolled in schools not offering physics or chemistry. It is also shown in this publication that the ratio of pupils who took chemistry to the total number of pupils in 12th-grade in 1954 was 31.9 per cent. While these statistics are not so discouraging as earier reports, many believe the situation is still alarming.

THE HIGH-SCHOOL PROGRAM

It seems clear that, if the needs of the future in science and technology are to be met, improved programs of science and mathematics will have to be offered in the schools, and there must be a general improvement in the teaching of science and mathematics at all levels, from elementary school through graduate study. It is felt that, with good teaching and adequate programs in high school more boys and girls will be interested in the study of science and mathematics in preparation for future lifework, and there will be much more adequate understanding of science on the part of the general public.

In considering high-school programs of science, it is necessary to think of three groups of students. The first is the gifted group, with special ability and interest in science and mathematics, who will finish college courses with scientific majors or in engineering, and some of whom will continue to graduate study in preparation for research.. The second responsibility of the high-school science teacher and program involves the place of science in general education. Few would deny that intelligent citizenship of this decade and in the future will require a better understanding on the part of all people of science and mathematics and their role in our culture. The third group of students includes those of lowest ability,

for whom schools are now providing in many instances special work which is sometimes referred to as "remedial" work.

It is not suggested in this paper that these requirements of our times make necessary a three-track program in science. Rather, it is suggested that in planning science programs is should be clearly kept in mind that there are these three groups, and that whatever program is planned must make adequate provision for all of them. It is now more universally accepted in mathematics, than in the other sciences, that a multiple-track program of some kind is necessary to provide adequately for individual differences. This is due particularly to the fact that students entering the ninth grade have had eight years of more-or-less formalized instruction in mathematics, and mathematics as traditionally taught is cumulative at all stages.

American high schools should furnish science instruction for the capable students which is comparable to that in European schools for young people of comparable age. Because of our interest in American high schools in providing for all students rather than for a select group, this has never been the traditional pattern. It will mean, of course, that there will have to be careful selection of students for these specializd programs, and that the students chosen for them will have to have carefully planned programs. The Study on Admission to College with Advanced Standing has already pointed the way in which we are likely to go in the next decade.

There has been no serious study of the problem of the desirable per cents of students who should be enrolled in physics, chemistry, or mathematics, either in terms of national needs and professional opportunities or in terms of ability levels. There are those who maintain that physics and chemistry, and at least three years of mathematics, should be required of all students in grades 9 through 12. This conclusion seems most unreasonable to others. It is contrary to the concept of the American high school that the program of students be determined by requirements. It is also contrary to the concept of many that students will do their most effective work in courses required of all. It seems much more reasonable to hope that an adequate supply of well-trained students in science and mathematics can be obtained on an elective basis through the improvement of course offerings and teaching, and that the elective system may also provide for appropriate general education. This problem of desirable percentages in secondary-school enrollment in science and mathematics needs serious study.

One of the most widespread criticisms of high-school science and mathematics is that these courses are behind the times. There is resultant interest on the part of all major scientific societies in modernization of the secondary-school programs in science and mathematics. This is a major interest of the President's Committee for the Development of Scientists and Engineers. The best solutions of this problem will come from joint effort of secondary-school teachers, administrators, and scientists.

More progress has been made in secondary-school curriculum study in mathematics than in the sciences, since a number of important studies in the mathematics curriculum are already in progress. These range in point of view from suggested reorganization of traditional subject matter to a rather complete replacement of traditional content. Developments in mathematics in the past century have placed emphasis on postulational approaches and on greater and greater abstraction and generalization. Materials for secondary-school courses which reflect these modern trends are now being experimented with in a number of places. While some see real advantage in these changes, others fear that the tendency to abstraction and emphasis on proof would take secondary-school mathematics farther away from secondary-school science than has been true. The developments in mathematics for secondary schools are of concern to all science teachers. These developments will also provide a pattern for curriculum study in science.

In both mathematics and science there is a call for greater emphasis on the discovery approach. Those now occupied with modernization of the mathematics curriculum believe that the proposed changes should result in much less emphasis on isolated techniques and memorization in mathematics, with more opportunity for the pupil to develop the ability and disposition to think mathematically on his own. The place of discovery in teaching science has never been questioned. This, of course, is the heart of the science laboratory approach. In this respect modern needs in science bring high-school science teaching into close agreement with the best that learning psychology suggests for teaching. Science fairs and clubs make it more possible for the individual to work on his own, and they must be considered of increasing importance in any efforts to meet the needs in science of our time.

Increased use of science consultants should be one means of strengthening science teaching and programs, especially in this period of transition. Only three states (New Mexico, New York, and North Carolina) have science consultants on the staffs of the

State Department of Education. While a number of large school systems are making use of consultants, the practice is far too limited. A competent teacher consultant can contribute greatly to improved daily classroom methods, to program and course modernization and improvement, and to better planning of laboratory facilities and their use. In a time of probable increased teaching loads and greater use of teachers on emergency permits, schools can materially increase the effectiveneess of their offerings by a more adequate provision for supervision in science. One of the principal activities of the Science Teaching Improvement Program of the American Association for the Advancement of Science is a Study on the Use of Science Counselors. In this Study the counselors or consultants will be members of state university staffs and will work with schools in cooperation with State Departments of Education.

ASSUMPTIONS FOR ACTION

In this paper the situation in high-school science teaching has been briefly analyzed in terms of manpower needs and their implications for science programs. That the problem before us is a difficult and critical one cannot be denied. That the public interest in the schools, and in this problem in particular, not only demands action but provides unprecedented support for constructive improvement of science teaching in order to meet the needs of a rapidly changing society, is also evident. A basis for action is suggested by the following assumptions:

1 There is a shortage of capable and well-educated persons in all major areas of national life, and this shortage promises to be very serious, especially during the next decade.

2. The future of American progress and development depends upon adequate science and mathematics programs and teaching in the secondary schools.

3. The quality of teaching can always be improved, and the challenge of our times makes it necessary that teachers of science and mathematics seek every opportunity for improving teaching, and thus interesting more boys and girls in science and mathematics, and more adequately preparing the needed manpower in this critical area.

4. Science programs must be planned to make more adequate provision for all students attending our high schools.

5. Continuous study will be necessary in order to keep secondary-school curriculums in science and mathematics up to date. These studies should become the responsibility of high-school

teachers, school administrators, and scientists working cooperatively.

6. Consultant services to teachers can make a major contribution to the development of good programs and the improvement of teaching. The needs of our time demand that consultant services in special areas, such as science and mathematics, be provided in large systems and on a state-wide basis.

7. The magnitude of the task ahead makes it necessary that high-school teachers of science and mathematics participate in the professional organizations in their field, and in major state and national teacher organizations.

A Classroom Teacher Looks at Science-Teaching Objectives

MARY POLK ROBERTS
Towson Senior High School
Baltimore County, Maryland

THE TEACHER of science today is plagued too often by inadequate laboratory facilities, oversized classes and heavy schedules consequent upon the shortage of science teachers to have time for reflection about what he is doing and why. The long range aims of science instruction that he committed to memory as an undergraduate he either has forgotten or wishes he could forget. Not delivered by such merciful amnesia from an examination of his daily efforts in relation to his accepted goals he is likely to suffer from feelings of guilt and frustration. Consider a fairly typical list of science teaching objectives:[1]

1. Meeting the needs of adolescents in the area of personal living
2. Meeting the needs of adolescents in immediate personal-social relationships
3. Meeting the needs of adolescents in social-civic relationships
4. Meeting the needs of adolescents in economic relationships
5. Encouraging reflective thinking

While we would not question the desirability of achieving these goals, despair or cynicism is likely to be the lot of the teacher who scrutinzes his students for evidence of progress in all these areas. Other lists of objectives are no less disheartening when we

[1] Thayer, V. T., et al, *Science in General Education, Part II*. New York: D. Appleton-Century Company. 1939.

use them as yardsticks for measuring the real outcomes of our teaching. And yet, if we reflect at all, we must be able to give ourselves some reasons for our daily or weekly or even yearly classroom procedures. The moment we seriously undertake to do so we set up our own list of objectives—perhaps not as comprehensive as the textbook or course of study variety but almost certainly more concrete, probably less optimistic and more in keeping with our personal convictions and capacities. Most often the goals we set are the ones we feel we have the best chance of attaining with our own particular strengths and weaknesses. Some teachers excel in techniques of imparting information, some in providing guidance and personal inspiration to students, others in fostering the development of rigorous habits of thought. The list could be extended indefinitely. What is common to all good teachers is their success in bringing about some desirable change in the attitudes and behavior of an appreciable number of their students. The nature of these changes reflects the aims, whether formulated or quite unconscious, of the teacher. Toward what kinds of objectives can we, as teachers, reasonably expect to see evidence of progress? The following enumeration is fragmentary and based only on the experience of one teacher. Doubtless, most teachers would be able to extend and modify it on the basis of their differing experiences.

Increased Interest

Good science instruction can reasonably be expected to result in a definite increase in most student's interest in science. Some students come to the science classroom wth a preconceived preference or aversion for science. Most come in a neutral state and for the purpose of meeting an academic requirement. Science instruction can stimulate those few in any group who have the desire and the ability to dedicate themselves to science as a life work. Most students can be brought to a degree of intelligent interest in science that is desirable in non-scientist citizens. A few cannot be won to interest by any blandishments but these are a small minority. Some facet of science in the hands of a competent teacher is likely to capture the interest of all but the most recalcitrant. A student's increased interest in science is apparent in the type of questions he asks as well as in reading and activities that he undertakes beyond the requirements of superior classroom performance.

Acquisition of Information

The acquisition of scientific information is another legitimate, if often unmentioned, goal of science teaching. The cliché that we

are teaching children, not subject matter, is at best a half truth. We do not teach children in a vacuum. The subject matter is a medium through which attitudes and ideals are developed. It is also an end in itself. Because curiosity is an innate human quality, very few students fail to respond to the enthusiasm of a well-informed teacher leading them through the beauties and mysteries of his chosen field. Teaching technique unsupported by a broad background of knowledge cannot satisfy this desire for information. A teacher who is thoroughly trained in his own subject is more likely to present it in an interesting and comprehensible manner. Student progress toward mastery of subject matter and ability to apply knowledge in the solution of unfamiliar problems can be determined by the judicious use of more or less conventional testing procedures.

Awareness of Problems

Scientists today are increasingly aware of their obligation to inform the public of the social consequences of scientific advances. Teachers of science have a unique opportunity and consequently a double obligation to help an entire generation toward an understanding of the importance of science in their own lives. This involves more than a child-like joy in the gadget value of scientific progress. It involves a recognition of the great promise ond perhaps even greater danger that lies before a human race whose social and ethical progress is not yet abreast of its scientific know-how. The use of nuclear energy even for constructive purposes involves some threat to human health and genetic integrity. In the event of extensive automation, a vast number of individuals who cannot master complex skills will be unemployed and unemployable. Improved medical care contributes to growing problem of overpopulation in many parts of the world. Pure research, the life blood of science, depends more and more on government subsidies that can be granted or withheld by a voting citizenry. Few adolescents identify these problems as their own without guidance. Fewer still revert to complacency when their attention has been directed to great issues.

Application of Scientific Methods

The classroom teacher can also reasonably expect to see progress in the application of scientific techniques to problem solving. The laboratory affords golden opportunities in this area but conventional laboratory procedures are too often not only unscientific but anti-scientific. I refer to laboratory exercises in which

the "right" results of an experiment are obtained or fudged by following a detailed set of instructions. Experimentation of this type occurs nowhere on earth except in school and college laboratories. The road to new scientific knowledge is neither so smooth nor so straight. If laboratory teaching is to approximate scientific investigation, it must start with a problem the students do not know how to solve and proceed through errors and blind alleys to a tentative solution. Students need explicit instruction in some fundamental laboratory techniques if burned fingers and ruined equipment are to be avoided but they also need practice in devising methods, in making mistakes and trying to correct them. They need to face the dilemma of results that aren't "right" and to attempt to analyze the uncontrolled variables that produced gunk instead of fine crystals. A student's devoloping tendency to do a bit of elementary literature searching or preliminary reasoning when confronted with a problem can be readily observed and encouraged.

Selection of Careers

In the face of our present national shortage of scientists the next plausible goal seems more important than it would in times of plenty. Students should be informed about the great need for trained scientists and about the opportunities and requirements of a scientific career. A recent informal newspaper quiz conducted to determine students concepts about scientists showed some amusing if startling misapprehensions. The scientist emerged in this picture as the baleful genius stereotype that Terman's studies should have banished years ago. This may simply reflect a current distrust of all intellectual excellence in an age when the scientist is a conspicuous target for such disaffection. It is in any case a mildly poisonous notion for which antidotes are needed and usually available. At close range the scientist is very much like other people and, in most cases, not even menacingly brilliant. Colleges and industries often provide opportunities for students to see scientists at work and to hear them talk about what they are doing. The resulting change in attitudes is usually salutary. Careers in science have many attractions and, like any other career, some disadvantages. Students who know what is involved in scientific work can elect it or reject it on a realistic basis.

Toleration of Uncertainty

Another goal of science teaching, suggested by the late A. N. Whitehead, is to combat what the philosopher called the fallacy of

dogmatic finality. In this phrase, Whitehead identifies a persistent human tendency to accept present knowledge as ultimate knowledge. A capacity to recognize the tentative nature of scientific "truth" and to abandon old strongholds of belief in the face of new evidence is an essential ingredient of scientific progress. Can this be taught? Perhaps only negatively by pointing out to students some of the false certainties that have enslaved men's minds in the past. More positively, by making it clear that our present best information in some areas may be obsolete tomorrow and by emphasizing the challenge that this implies. Evidence of emerging ability to tolerate uncertainty is not often clear-cut but we can detect an increase in the student's ability to identify and resist dogmatism in his own attitudes as well as in the attitudes of others.

No doubt some of the ground that we seem to gain with our students is subsequently lost. Some of our seeming progress is illusory. Some of our efforts are palpably in vain. If we have done our work with sincerity and conviction something remains—a wisely chosen career, a consuming hobby, a changed attitude, an improved technique. We may not have achieved all the objectives in the textbook or even all of our own personal ones but if we have effected some desirable modification of behavior we have earned our salary and expiated our sins of omission for one year.

Opportunities in Science for Bright Pupils

WALTER S. LAPP

Past President, National Science Teachers Association

A RECENT SURVEY[1] of 15,000 high school pupils in all parts of the United States by Purdue University indicates that most students enter high school with such a distaste for science that they tend to shun careers in this field. According to this study about one-fourth of our high school freshmen think that scientists as a group are "odd." Some think they are actually "evil." While the picture may not be as dark as this survey paints it, we had better heed the warning. Other studies show similar trends in thinking by our students. It is the purpose of this paper to discuss a few ways by which we may encourage more of our talented students to take advantage of the many opportunities science offers.

[1] Remmers, H. H., Educational Reference Division, Purdue University.

Serving informally as a guidance counselor is a very important part of the teacher's job. The science teacher, in particular, has many opportunities to correlate subject matter with problems in science. This applies to the terminal students who may become technicians in hospitals and research laboratories as well as to the college-bound who will become scientists and engineers. There is great need in many fields for intelligent technicians, both men and women. It is these technicians who under supervision carry on much of the research of the day.

We shall first present several case histories of well known scientists who recognized opportunities and problems in science and took full advantage of them. These examples will serve to illustrate some of the methods and techniques the scientist uses. Teachers can find many other case histories which they may use with their classes. An excellent book to illustrate how great scientists of the past recognized and grasped opportunities may be obtained free by writing to General Motors.[2] Another *must* book for those looking for opportunities in science is Osborn's *Applied Imagination*.[3]

Case 1

Let us begin with the story of the neon sign.[4] Early in this century Sir William Ramsay—who had previously discovered neon, argon, krypton, and xenon, the rare gases of the atmosphere— lectured on them in Europe and America. He demonstrated their inert properties and stated that they were mere scientific curiosities with no probable use. He was asked how he knew these gases were pure substances and not mixtures. He answered by passing an electric charge through a series of sealed tubes, each containing one of these gases. In each tube appeared a glow with a distinct but different color. The effect with neon was especially beautiful, being a brilliant orange-red light. This was proof enough, explained Sir William, because it was known that every pure substance, heated to incandescence, produced its own kind of light.

Thousands of people, who were thrilled by these lectures and experiments, applauded and then went home and forgot all about them. But the effect on Georges Claude, a French physical chemist, was different. He was so fascinated and intrigued that he kept thinking about them until a great new idea came to him. Claude, you see, was in the business of producing oxygen by liquefying

[2] Kettering, Charles F., *Short Stories of Science and Invention*, Educational Relations, General Motors, Detroit 2, Mich.
[3] Osborn, Alex F., *Applied Imagination*, New York, Charles Scribner's Sons, 1953. Principles and Procedures of Creative Thinking. An excellent list of references is included.
[4] Bichowsky, F. Russel, *Industrial Research*, Brooklyn, N. Y., Chemical Publishing Co. Inc., 1942.

air. Neon and the other rare gases were byproducts of this process. After a lot of thinking and all of sudden, Claude's mind gave birth to a new industry that has transformed our cities from drab dark places to bright and gay ones. This industry employs thousands of workers and makes living more pleasant for millions. And since neon is also used in beacons, it has doubtless saved many lives on both land and sea.

The technique of invention has several aspects. One is a strong interest in a problem. Another is an understanding of the basic principles of science. The birth of an idea has been described as a "flash of genius." This flash is generally the result of long and hard thinking. And it is the work of an individual. Research teams produce remarkable results in many areas. However, the basic discoveries can generally be traced to the creative thinking of an individual member of the team.

Professor F. S. C. Northrup[5] of Yale University puts it in these words:

> Thick-skinned people do no creative thinking; to them everything is understood, they have no problems, nothing baffles them. . . . We must start with a thorn in the flesh, a disturbance, something baffling. Without it there will be no creativity.

Case 2

One hundred years ago in 1856, William Henry Perkin (1838-1907)[6] at the age of 18 discovered mauve, the first known aniline dye. This was the beginning of the giant industry we call synthetic organic chemistry. It is now a multibillion dollar world-wide industry and produces nearly three-fourths of such products as dyes, drugs, medicines, resins, plastics, paints, soaps, detergents, and rubber.

And it started with a teenage boy who was inspired and encouraged by his teachers. At 13 while attending school in London young Perkin heard that a lecture in chemistry was to be given each day at noon. He promptly gave up his lunch period so he could attend. Some of his friends thought he was queer. His father, a builder, wanted him to become an architect. But the more lectures on chemistry he heard, the more certain he was that he wanted to become a chemist.

Somewhat earlier a German chemist, Professor A. W. Hofmann,[7] set up a chemical laboratory at the Royal College of London. Be-

[5] *The Nature of Creative Thinking*, A Monograph, Sponsored by Industrial Research Institute, Inc., 60 East 42nd Street, New York 17, N. Y., 1952.
[6] Slosson, Edwin E., *Creative Chemistry*, New York, The Century Co., 1920.
[7] *Encyclopaedia Britannica*, 13th Edition.

cause of his unheard of interest in chemistry Perkin at the age of 15 was permitted to enroll in Professor Hofmann's class. Within two years he was made an assistant to the Professor. One day Hofmann suggested that some student might attempt to make synthetic quinine.

That was enough. Perkin at once made it his project. In order to enable him to work evenings and on holidays, he set up a crude laboratory in his home. He intended to make quinine. He met with many failures but kept right on trying. Then during the Easter vacation of 1856 he heated a mixture of aniline sulfate (derived from coal tar) and potassium bichromate. The result was a discouraging black precipitate. But when he tried to wash it out of the beaker with alcohol, it turned into a beautiful purple solution. Here was something new and unexpected. He repeated the experiment and obtained the same result. He had unintentionally made a new substance, the first aniline dye, later named mauve.

Perkin now at 18 appreciated the commercial possibilities of the new dye and took out a patent on the process for making it. He left college and built a factory for manufacturing mauve and other dyes. His business prospered for many years but later he returned to research in pure chemistry.

It is interesting to note that quinine was not synthesized until 1944. While Perkin did not succeed in making it, he accidentally discovered an important process for making dyes. It was much like Columbus failing to reach India but discovering a new continent. Discovery by accident is now called Serendipity. The true scientist observes and records everything that happens in an experiment. It is probably safe to say that he learns something from every experiment he performs regardless of the outcome.

It seems timely to point out that the coal tar industry did not prosper in England as it should have. The great universities were not interested in the advancement of science. They trained very few chemists. When Professor Hofmann failed to be supported in his research, he decided to return to Germany. This was in 1864 and he took with him the new knowledge of synthetic organic chemistry. Then within a few years Germany became the chemical leader of the world in both industrial and educational circles. How different the history of this century would most likely be if England had encouraged her scientists and developed the new industry to which she gave birth.

Modest Research in High School

As generally taught high school science stresses the history of science. Most laboratory work consists of cookbook procedures for repeating certain traditional experiments. Such methods serve a useful purpose in learning facts and principles and some laboratory skills. They do not, however, go far enough with the more talented students who have what it takes to pioneer into unexplored country.

All science teachers should provide facilities for this latter group to carry out their own original projects. They will have to plan their own experiments and work out their own procedures under the guidance of their teachers. In this way they will learn that *science* is a name for any method or process of finding out new truths that no one knew before. As Still of George Washington University[8] puts it, they will be learning to do "research at the grass roots."

The Teacher Is the Key

Most scientists can trace their first interest in science to some sympathetic teacher.[9] One illustration will have to suffice. Dr.Robert E. Hulse, who is a Vice-President of National Distillers and who is responsible for building up the chemical department of that company, is quoted in the August 19, 1956 *New York Times* as follows:

> I was in my last year at high school expecting to study civil engineering at Rutgers when I took the regular high school chemistry course. The teacher we had made it all sound so very interesting that over night I knew that I wanted to learn more.

Most teachers of a few years' experience can point with pride to the scientific accomplishments of former students.

More and more teachers are seeing the light and are encouraging their talented pupils to work out projects for science fairs. Nearly 200,000 science students exhibited their completed projects at the various science fairs of the United States this past spring.[10] More teachers are also getting their students to enter such programs as Science Achievement Awards conducted by the Future Scientists of America Foundation and the Westinghouse Science Talent Search conducted by Science Clubs of America.

[8] *Science*, Volume 124, Number 3218, 31 August 1956.
[9] Brandwein, Paul F., *The Gifted Student as Future Scientist*, New York, Harcourt, Brace and Company, 1955.
[10] *Science News Letter*, Volume 70, No. 15, October 13, 1956.

Some Fertile Fields

We constantly hear of the need for more scientists and engineers. The following are some of the specific needs that have recently come to the attention of this writer:

(1) *Physics.* The needs are especially great in such areas as atomic energy, aviation, electronics, guided missiles, and rockets. Look up the recent predictions of David Sarnoff. In the past his predictions have been accurate.

(2) *Biology.* This field is as wide open as all outdoors. Recently Professor Harold C. Bold of Vanderbilt University told the writer that there are only four or five people in the whole world who know enough about soil algae to identify an appreciable number of them. Who knows? Maybe soil algae will be the basis for new industries. Recall that within the past 25 years soil fungi have made possible the half-billion dollar per year antibiotics business.

(3) *Medicine.* Many sections of this country do not have an adequate number of physicians and dentists. According to Dr. Toffelmier the need is still greater in other countries.[11] In Java for instance there are fewer than 2,000 physicians for a population of 80,000,000. This is less than one physician for 40,000 people.

(4) *Chemistry.* Chemists believe that many millions of compounds can be made by man. To date fewer than one million have been made.

(5) *Biochemistry.* It will take many centuries to study the effect of all compounds on all plants and animals. The possibilities here are almost infinite. Right now gibberellic acid derived from a fungus is being studied. One part per million will increase the growth of such plants as roses and sweet peppers.[12]

(6) *Patents.* Mr. Sam W. Kingsley, Personnel Officer of the U. S. Patent Office has recently stated[13] that the patent field offers one of the most satisfying careers available to the young engineer and scientist. Young scientists can start as examiners in the patent office. By going to law school at night they can in a few years become patent attorneys. Kingsley states further that the salaries of patent attorneys are in the upper one-percent of all corporate salaries.

(7) *Education.* We can hardly have scientists without science teachers. Few careers afford greater opportunities to serve society.

[11] *The New York Times*, June 10, 1956.
[12] *Agricultural Research*, United States Department of Agriculture, September 1956.
[13] *Age of Science*, Volume 1, No. 1., An annual guide to Current Developments and Future Opportunities in Science and Engineering. Compiled and Edited by Students at Yale University, New Haven, Connecticut, November 1955.

On September 2, 1956 A. J. Carlson, Emeritus Professor of Physiology at the University of Chicago, died at the age of 81. Carlson was on the greatest science teachers of all time. Victor Johnson of the University of Minnesota[14] says of him:

> Scores and hundreds of medical students remember Carlson as the greatest influence in their scientific experience. . . . He continued unremittingly to fight against ignorance and superstition, disease and death—against quacks and quackery, alcoholism, antivivisection, and the process of aging.

What higher tribute could be paid to any teacher or to any man? In the future opportunities for promoting human well-being will probably be as great in education as in any other field.

Non-Test Evaluations of the Outcomes of Science Teaching

JOHN G. READ
Professor of Education, Boston University

IF THERE WERE to be but three question asked of a science teacher at the beginning of the school year, seeking to evaluate his teaching his course of study, they might be these:

May I see your list of goals for today, for this week, and for this marking period?

May I see your folder of special projects, reading, and problem-solving situations for your able students?

May I see your final examination for the year?

And the questioner would be fortunate to escape with his life! Nevertheless, these are sensible questions. They should be answerable in part every year; and after a teacher has had some years of experience, should discover a framework for science teaching under the confusion of daily classroom chores. Similarly, the perennial question, "What do you do about grades and a marking system?" is the basis for school shop-talk wherever teachers gather. The need for accurate communication of evaluation from teacher to pupil to parent to pupil to teacher is known to everyone. Grades, with their multiple meanings, are poor things. What do "76%," or "S_3," or "A−" mean, even with footnotes that take up half the report-card? Each of these can be, almost inevitably is, contaminated with hidden meanings. There are three classes of meanings.

[14] *Science*, Volume 124, Number 3225, 19 October 1956.

(a) The first is the punitive aspect. Failure grades are given as punishment because a pupil did not do as he was asked to do. He behaved badly. He disrupted the class. Perhaps if he had been in a different school environment he would not have been so out of place. Perhaps schools now can help him little. There should be no criticism of a failure mark that is decided upon by teachers and school staff as a symbol of failure of the pupil and the current available school community to cooperate.

The mark which is just under a dividing-line is often punitive, or at least is prodding. The A−, the 79%, or the 69% (you just missed passing) are hard to justify. They are often used to stimulate a burst of frenetic activity for the next marking period. But perhaps there are other and better means of stimulation.

"Marking on the curve" has some aspects of pressure. It implies that the seven percent of A's in a normal distribution must have seven percent of failures at the other end of the curve. When more than half of the school population has left before the last two years of the secondary school, when whole cities or towns have the best of their young minds in school, marking on the curve is not the way to improve achievement. How much more illogical is the grade on the report card which cannot be explained by the pupil to the parent—or worse, by the pupil to himself.

Whatever marks mean, they should be acceptable to pupils. Neither punishment nor prodding are best done by report cards.

(b) Second, are marks for selection and classification. These are honest and helpful. They are records for the future, telling pupil, parent, and later teachers that this young person should be able to go on in science. At the end of a semester, teachers with reasonable numbers of youngsters in their classes can classify them easily. Without any records of performance, superior students can be grouped, often in exact rank order. Likewise, those who have not "done satisfactory work" in the teacher's estimation can also be grouped and ranked. But the middle group has indistinct outlines. Perhaps five percent of this group will be misjudged by the teacher without the help of records. Teacher-made tests, anecdotal records, and national norms on standardized tests are really needed only for this small percentage of the class. Errors in group placement are most often found between the low and middle groups, but there are occasionally surprises at the other boundary. Joe has done little homework. He is apparently disinterested in class discussions. But he gets next to the highest mark on the final examination. Lazy? Rebellious? Or has he been quietly reading *The Scientific American*

behind his biology book during class? It could be that he is a good companion in scholarship, bored because the class moves so slowly. And once in a while test marks are frauds! Youngsters have been known to keep just under the "A" level through choice, for top grades sometimes mean more assignments which are time-consumers instead of challenges. Perhaps these young adults should get high grades for adaptation to the system in which they find themselves.

(c) Rewards. For the past thirty years it has been slightly immoral to consider marks as payment for work done. No school is there but has fought the battle of the report cards. The pendulum has swung between the extremes of the 76.45% type of grade, to the personal conference with every parent and pupil where numbers and social conditions permitted. Nevertheless, there is a real hierarchy of excellence in every group and in every subject. Science may have a more pronounced one than any other subject except mathematics. Ideally, teachers should be able to say, "If this pupil likes science and wishes to go on with it (and we have found that he has ability in mathematics), he will almost certainly be a success." That time is not yet here, but it is approaching. Local scholarship competitions, the Science Talent Search, North Central Association, Regents and College Entrance Examination Board screenings, and the action research of the large test-making firms come closer and closer to the discovery of those characteristics which make for success in science in adult life.

Scholarship excellence often adds up to tangible, even monetary rewards. National Science Foundation plans, and legislation in many states and in Washington, point to a time when no science-able boy or girl will lack knowledge of his ability in science, and if able, will then lack funds to utilize it in college if this is consistent with the mores and desires of his community.

The section on *rewards,* then, suggests that there should be regular scientific testing of ability and achievement with "rewards" in the form of highest grade-symbols for encouragement, friendly fatherly insistence on high quality of scholarship, not only in science, but in all subjects for the able science pupil. Rewards can also be classmates' approbation, adult contacts which will stimulate and challenge, and opportunities to obtain public recognition through the press or through membership in groups which have public audiences to praise them.

It has been admitted, in this discussion, that grades plus an X-factor of personal communication from teacher to pupil (involving the parent, of course) are important. What systematic steps can

a *school system* take that will convince teachers of the worth of the superior science student? This discussion will now be concerned with the superior *science* student, but it does not negate the need for superior poets, journalists, statesmen, automobile mechanics, businessmen, or housewives. It is about superior science students, because science teachers have to be concerned about them; for in spite of the national alarums about the shortage of scientists and science teachers, it is still the classroom science teacher who will implement any changes in the situation.

What of the point that it is not democratic to divide, as the writer obviously has done so far in this article, all students into those who are able and superior and those who are not? In the first place, making sure that able students are guided, challenged, and conserved is a matter of national, or rather international, survival. The problems of the world are not going to be solved by science alone; but they are not going to be solved without science. Free-world men and women of good will are needed *to the limit of our strength and numbers* just to keep us going in the next century. The boys and girls who will do this are in our classrooms right now. In the second place, a planned program for the superior student will not take time away from all the others It can even make the teacher's energy available to those who need desperately to understand the place of the scientist in the world today, and need to have a knowledge of the processes of science. We are still not comfortable with these processes. We are glad of the gadgets they have produced, but fearful of the fury they can loose. Children, young people, and adults need to respect the scientist and the teacher of science as men and women who are a little different, as the poet is different, as the wonderful bundle of brains and coordination which is the great athlete is different; to respect them and be glad they stand guard against ruthless forces which could overwhelm us. These are the forces of non-sentient nature, and the forces of groups which care little for mankind.

If we bring this problem down to the classroom, we can see that applause for achievements of the science-able pupil should come as naturally as for the athlete or the social leader. It will, given the proper climate. Not long ago the writer was giving out national awards from the *Future Scientists of America Foundation* of the *National Science Teachers Association.* These awards, medals, United States Savings Bonds, are contributed by the *American Society for Metals.* A recipient of a gold medal and a $100 bond had been brought back from college to receive them. His parents were

there. His junior and senior high school science teachers were there. And so was the championship football team of the high school, fresh from a victory over its traditional rival the day before. All were gathered in the assemby hall with the student body. The mayor spoke, the principal spoke. The team got its letters. There was enthusiasm, cheering, good feeling. Then the science award came. The boy spoke. More applause, certainly as vigorous, as little self-conscious as that for football. Finally, the junior high science teacher was introduced. Three years before, he had encouraged this boy. And he had had almost every pupil in that hall in his classes—in a classroom that had torn dark curtains, makeshift apparatus, traditionally fixed furniture. He tried to speak. For five minutes that audience stood on its feet to applaud him and to tell him that they believed it was possible for this slight bespectacled science-able youngster to do as much for them as would their athletes—and to say goodby because they were losing him to a community that understood his value more than did their town.

No, the rest of the class will not lose out if we care for the scientist-to-be. He will not only help in the future, he helps while he is in the school. He will become the teacher at times; he will lead a science club in which there are many other kinds of folk than scientists, but who will forever see more in the rocks, the flowers, the sky, or in beautiful machines because of their associations in the club.

And now what of some practical ways of evaluation in which all pupils can be encouraged to climb as high as they can, and more will want to climb to their own maximum height? It will not be because of tests, although they can be used to help. It will not be because of punitive or prodding report cards. It will be because of some of these seven plans or activities which follow. Pupils can be evaluated because:

(1) There is set forth by the teacher a precise and clear exposition of what the purposes of the immediate tasks in science learnings are, so that every pupil knows *what* he is expected to do, and *why* it is good for him to do it. One of the greatest tragedies in secondary school teaching is that pupils are not told what the work they do is all about. No matter whether the textbook, or a guide sheet, or an outline on the board is used, delimit the task, and make known the adult position of why this day's work is taking up the time of young and vigorous entities.

(2) There is a clear understanding as to what the most important outcomes are to be, and how they are to be measured.

If there is more material than can be covered adequately in the time available, then teacher and pupils should know what is to be omitted. The hardest task of the teacher is to decide what to leave out, not what to teach. Textbooks are not helpful in this matter. Publishers produce books which try to satisfy everyone they can think of. Committees making courses of study should start by buying razor blades to cut out whole sections of texts.

(3) There is a body of written material describing special projects, suggestions for readings, reports, demonstrations, visits, conferences, field trips, audio-visual aids, debates, assembly programs, and experiments. These are graded in difficulty and complexity. They are available to all. Some are challenging to the brightest pupils.

(4) There is a vigorous science club with a broad base, even in a narrow area such as physics. There is in it a place for talents of many kinds, for writing, for research, for art, for history, and for technical competence. There is a generous room and enough time for this, and the energy of a teacher who has not had to expend it all in non-teaching duties nor in an impossible burden of large classes.

(5) There is full information about, and adequate clerical help in, the participation in local and national competitions. Many of these require preparation for a year or more. Science fairs are as much a part of the total evaluation picture as are tests, and no schools can be said to have a complete evaluation program in science without something of the spirit of the science fair, where projects are made and exhibited. The smallest school can have its own, and parents will come to help in the evaluation by their appreciation.

(6) For those young people who are going on to college, there is careful tutorial teaching. In small schools, correspondence courses may help if no teacher of chemistry or physics can be found. Special outlines (commercial ones are excellent), lists of problems and questions of the type to be found on standardized examinations are valuable. Many trial runs of examinations of this type should be made. Practice "pressure sessions" with time-limits can be undertaken by groups of pupils. Some weeks of college-type lectures, near the end of the senior year, teach pupils how to extract ideas from such lectures, and later give them back in the traditional college-type examination. It is quite possible to raise a college grade by five to ten percent merely by knowing how to translate the work

of a week or a month into acceptable performance on an examination, all other factors of intelligence and ability being equal.

(7) There are constant opportunities for problem solving. Many of them occur in the carrying out of the six activities listed above. In addition, the teacher places in the path of pupils many social, scientific, and purely intellectual problem-solving situations. From the teacher's own background reading and his experience come many standard problems, each peculiar to its own area of science. In addition, emergencies, contrived crises, and unplanned-for natural events in the outside world offer challenges to able students. It is significant that national committees of teachers, often advised by scientists, are working on plans to do more problem-solving teaching in the schools. The kind of classroom most conductive to this is sketched by inference in the six activities above.

It is possible that a relatively few problem-solving activities, carefully validated and graded, will more surely discriminate among seemingly high-level students than will scores of items on the usual type of test. It is not impossible that a single situation, solved with skill and imagination by a pupil, might be all that is necessary to distinguish him from most of his fellows. It does not follow that failure to succeed would bar him for further trials (this largely because of varied experiential backgrounds); nevertheless, very few situations of this sort could have high reliability as well as validity.

It is with respect to these seven points that real evaluation takes place. Pupils show their interests and abilities more clearly. All can achieve; few get lost or are hidden; able pupils stand out so all can see them. The test is not eliminated. The recitation is still here. Class responses and homework are all part of the process. But these merely serve to help the teacher make judgments in the seven areas. There is no substitute for his knowledge of the individual. If classes are too large for this, the community can make sure they are smaller; if the teacher is too busy, the community can see to it that he has help; if the school does not have time nor space for this kind of science teaching, then tests and grades and report cards will not take their place. Children and young adults will not be the teacher, the community, and mankind for youth will not served; the community will not be served; and humanity will be the poorer. The thoughtful care of the teacher, the community, and mankind for youth will not have a better recompense than when it is directed to those young people who will serve the world through science.

Helping Students Develop Scientific Methods

JOHN B. CHASE, JR.
University of North Carolina

BASIC IN good science instruction is problem solving. Whenever one finds good instruction in a science classroom, one will find evidence that students have been engaged in defining problems which have been created and identified by student interest in natural scientific phenomena or stimulated by teacher initiated activities.

There will be evidence that students have gathered pertinent material from many sources. Materials and information will have been evaluated on the basis of its pertinence to the problem, the authenticity of the source, its reliability, and its validity. One will also find that students have planned and carried out laboratory experiments which revealed new information and confirmed old facts and principles. Information related to the problem will have been collected and organized in many ways. Students will have interpreted the organized data, and generalizations and conclusions will have been stated on the basis of present data. Through reading and laboratory experiences, generalizations and conclusions will have been tested and retested. One will also find evidence of the students' understanding and ability to make worthwhile application of principles and generalizations.

One will find evidence not only that students have engaged in methods and activities as described above, but that they have worked in an atmosphere of creativity. The classroom will lend itself to permissive working relationships, and students will have been stimulated to seek facts before drawing conclusions, to change opinion with new evidence, to respect the work and opinions of others, to observe and report accurately, and to sense cause and effect relationships.

The wise teacher utilizes the possibilities of natural problems to be solved and also recognizes and stimulates the natural desire of students to explore, to question, to try out or to experiment, and channels eager curiosity into worthwhile learning activities. This type of experience might occur in any science classroom. There are unlimited possibilities for good teachers to give students oppor-

tunities to define, analyze, and solve problems. And, therefore, the teacher can help the student develop scientific attitudes and the ability to use elements of scientific method in solving problems in and outside the classroom.

Many writers have presented different lists of scientific attitudes and elements of scientific method, any one of which would not be accepted by all. Elements of scientific method may best be defined briefly as the methods used by scientists as they work. This would, of course, not only include methods of work, but also techniques, materials used, and attitudes which are so interrelated that it is difficult to compose in general terms a conclusive list. It is with these limitations in mind, that the following are presented.

The Scientific Attitudes–

1. A respect for the opinions and work of others.
2. A willingness to change opinions when new evidence is presented.
3. The demand for evidence before drawing conclusions.
4. A curiosity about our natural environment.
5. A belief that every happening has a cause.
6. The demand for proof before accepting statements at true.
7. A desire to observe and report accurately.

The Elements of Scientific Method–

1. The ability to sense, identify, and define problems.
2. The ability to collect, organize, analyze, and evaluate information and evidence relative to defined problems.
3. The ability to propose conclusions from sufficient data.
4. The ability to interpret, apply, and test the facts and principles in many and varied situations.

It is necessary that teachers recognize these objectives as tangible and attainable. Too often, the above objectives are regarded as intangibles, and teachers, therefore, rely upon indirect methods and procedures for achieving them. Indirect teaching will not effectively produce the outcomes desired. To obtain the objectives of helping students develop the elements of scientific method and scientific attitudes, instructional procedures must provide direct experience in problem solving. Teachers recognize that providing such direct experience necessarily involves a way of living in the classroom. Only in a permissive atmosphere which leads to questions of "why," "how," and "what" can students develop the ability

to do causal thinking and to manipulate situations necessary for problem solving.

If the above objectives are regarded as tangible and attainable, teachers must first identify specific abilities which must be developed if the goal is reached. These abilities include skills, attitudes, and basic understandings which are ultimately expressed in behavioral patterns. Each teachers will want to identify and develop only those abilities which are of value and have meaning for each particular student or for groups of students. However, the following list of abilities, which are necessary if students develop a functional understanding of scientific methods, may be of value to the teacher as plans are made for individual classes.

1. The ability to sense a problem.
2. The ability to isolate scientific problems which grow out of social and personal relationships.
3. The ability to isolate the primary and secondary ideas and relationships in these situations.
4. The ability to express these ideas in clear, specific language.
5. The ability to recall past experiences which are related to these ideas.
6. The ability to design laboratory experiences related to specific problems.
7. The ability to manipulate laboratory equipment.
8. The ability to carry out laboratory experiments.
9. The ability to observe laboratory processes accurately.
10. The ability to record data.
11. The ability to interpret data.
12. The ability to recognize valid evidence.
13. The ability to interpret and understand relationships between data.
14. The ability to make tentative generalizations or hypothesis.
15. The ability to use many sources and devices as authoritative materials and experimental precedures for checking hypothesis.
16. The ability to find and select materials which are pertinent to the problem.
17. The ability to evaluate the materials selected.
18. The ability to organize, summarize, and present materials.
19. The ability to recognize cause and effect relationships in situations.

20. The ability to recognize errors and inconsistant data in interpretations.
21. The ability to make generalizations.
22. The amility to express generalizations in many ways, such as: charts, tables, drawings, diagrams, models, and narrative descriptions.
23. The ability to apply generalizations to modern usage.
24. The ability to apply generalizations to similar problems.

Teachers may easily provide opportunities for problem solving which require the use of scientific methods. It is not enough for students to read about a problem which has been selected either by the teachers of by students for study. Nor is it enough for students to give back to teachers ready made answers to a series of questions. Although much can be gained from reading and answering questions, it is necessary for students to engage in activities which give first hand experience in using scientific methods if the above abilities are to be developed.

For example, a science teacher may approach the topic, "Microscopic living Things in Relation to Human Activities," in the following manner so as to give emphasis to scientific methods.

I. *Identify the problem.*

The extent to which learning occurs or the degree to which an individual learns depends on the drives or motives that impel him to action. Motivation may be regarded as the aspect of teaching which supplies a dynamic urge for the individual pupil to take part in learning experiences and activities. It is an integral part of the teaching process. To help provide this motivation *introductory activities* are suggested. Such activities are intended to arouse the curiosity and interest of pupils to the end that they may sense the usefulness and purpose of what will be done later. The following types of activities may be helpful.

1. Arrange an exhibit of mold and bacteria cultures.
2. Have someone report on the life and accomplishments of Pastuer, Jenner, or Lister.
3. Arrange a display of pictures and clippings telling the story of current research in the use and control of microscopic organisms, new drugs, and sanitation.
4. Arrange for a student panel-discussion on health conditions in the school or community. Such as: "School Absences Due to Health," "A Recent Epidemic in————————," "How Our Community Attacks Health and Sanitation Problems."

As students engage in activities of this type, opportunity is provided for them to identify problems, isolate related factors within problems, and to identify and express relationships of cause and effect.

Introductory questions might be used to initiate discussion following introductory activities. These questions should be within the range of real experiences of the students and should be those which students can answer with reasonable correctness. The questions should create interest and a feeling of familiarity. For example:

1. How would you define or describe germs?
2. How large are germs?
3. How can you distinguish between a polluted and a non-polluted stream?
4. Does bread more often mold in summer or winter?
5. Why do farmers use clover and alfalfa in crop rotation?

Answering such questions is a process of recall. It is an early step in gathering information relative to a problem. Data or information should be recorded and used later when drawing conclusions and identifying other problems.

II. *Collecting data, organizing and evaluating materials.*

In this second step students collect information, and organize and interpret their findings. A great variety of activities may be used, such as demonstrations, field traps, experiments, reading, writing, and discussing. Materials may include films, charts, books, laboratory equipment, and specimens. During this stage in the study of the problem a teacher has a great opportunity to develop special interests and abilities of individual students. Certain individuals or small groups can work on phases of the problem while others work on another phase. Each student or group reports information gathered to the entire class.

Projects for individual or group activity may be used for each sub-problem. Many projects may be undertaken during the class period or as out-of-class work. For example:

1. Collect samples of water from different ponds in the area. Make drawings of and identify the microscopic living things present.
2. Make a survey of the species of microscopic plants and/or animals in a given region.
3. Make a chart or map of your community and school illus-

trating present conditions which are necessary for the growth of microscopic organisms.

4. Illustrate and describe the rust-barberry chain.
5. Collect as many articles as you can from current newspapers and magazines on research which is now being done on microscopic living things in relation to human activities. Display them on the bulletin board and report to the class what is being done.

Projects should help teachers care for individual interests and abilities, and for many students they should lead to a continuing interest which can be a leisure time activity or a possible vocation. Each activity, experiment, reading, or film should contribute to the solution of the problem and every effort should be made to keep students aware of purposes of the activity. Students should be encouraged to make careful records of all data and information.

III. *Propose and test conclusions.*

After the student has gathered and evaluated information he should draw tentative conclusions as answers to the problem. Conclusions may be tested by laboratory experiments which require students to expose the conclusions proposed to various conditions and varying factors. For example, students have read, discussed, and performed laboratory experiments about what microscopic living things need. They have drawn conclusions about the effect of heat, light, moisture, disinfectants and antiseptics upon bacteria. In order to test their conclusions in the laboratory, many experiments as the following may be performed.

1. Grow black mold on several pieces of bread and examine under the microscope. Place several slices of bread in various places—varying the amount of heat, light, and moisture. Compare the rate and quantity of growth of the mold on each piece of bread.
2. Grow bacteria in a petri dish and expose one-half of the area to the sunlight and the other half to darkness. Note the difference in growth.
3. To four different culture plates bearing macterial cultures add: lysol to one plate, 2% iodine solution to another, hydrogen peroxide to another, and carbolic acid to another. Use another plate untreated as a control plate. Examine each after 24 hours. Observe any differences if any.

Conclusions drawn from laboratory experiences may also be tested by the use of authoritative references, materials, and con-

sultants. By testing conclusions students should gain understanding and should be able to make generalizations.

IV. *Draw generalizations and apply principles.*

Once conclusions have been tested, students should be encouraged to draw generalizations and to apply principles to functional situations. This should require students to recall and use the facts and conclusions learned. By the use of *guides to application* students may be led to make applications by making models, charts, drawings; by writing papers; and by using other mediums of expression. Under certain conditions it may be possible for students to make applications through actual practice and real experience. *Guides to conclusions* are best expressed in question form, such as:

1. Why is it necessary to know the structure of the cell and the cell theory to understand microscopic organisms?
2. Why does refrigeration keep food from spoiling?
3. Why do most people have chickenpox only once during their life time?
4. Why is it undesirable to allow foods to become contaminated even if they do not become dangerous?
5. Why does the forest service encourage the killing of currants, gooseberries, and other Ribes?
6. What industries depend upon bacteria, yeasts, or molds?

Students may be stimulated to think scientifically and to solve problems logically only to the extent that teachers provide for such experiences by "doing science," as described above, rather than by just reading about science or by relying upon ready-made answers when questions are asked. To provide this type of experience, the classroom becomes a laboratory for solving problems. Laboratory group experiences cause students to examine causes and conditions, to share ideas, to discuss and evaluate differences of opinion, to look for facts and evidences, to look for strengths and weaknesses in their own ideas as well as in those of others. As solutions for stated problems are undertaken by individuals or small groups of students, skill in the collection, analysis, interpretation, and evaluation of data is developed.

Through this type of experience, students gain an understanding of scientific truths, and they gain a keener appreciation of the lives and works of scientists of the past and present. The teacher's role is one of motivating and guiding the learning process in order to stimulate scientific thinking and to develop skill in the use of scientific methods.

Audio-Visual Materials and Techniques

KENNETH M. MCINTYRE

Head, Bureau of Audio-Visual Education, Extension Division, University of North Carolina

FILM NOTES

*EGYPT AND ISRAEL, McGraw-Hill, 90 minutes, sound. Edward R. Murrow reports on the people, places and background of these two countries as well as the events leading up to the current crisis. Beginning with a brief review of the geography, Mr. Murrow turns to the history of each country, showing the economic, political, and cultural heritage of each. Heads of state as well as average citizens are interviewed for their opinions about the present dispute in the Middle East. The interviews highlight growing Islamic nationalistic tendencies, the Arab refugee problem, the Bagdad Pact opposition, and other problesm, The film concludes with interviews with Prime Minister Ben Gurion and Prime Minister Nasser.

PAKISTAN: ITS LAND AND PEOPLE, McGraw-Hill, 17 minutes, sound, color. East and West Pakistan, though separated by India, share the common belief in the future of their young progressive nation. Each is a democracy with its own elected leaders. Pakistan is predominately Moslem, although other religions do exist. The economic structure, agriculture, and trade with the United States is explained.

*THE VICE PRESIDENCY, McGraw-Hill, 51 minutes, sound. Edward R. Murrow's probe of the most neglected office in the United States is more than just a history: it studies the rights and duties as well as the men who served in this high office from John Adams to Richard Nixon. The Founding Fathers inteded it as an office for the man next best qualified to be president. The film shows how the two-party system and twelfth amendment changed this conception, and the present prestige of the office. Comprehensive in scope, authentic in treatment, this is an important film.

PARIS ON THE SEINE, Rembrandt, 17 minutes, sound, color. As the artistic center of the world, the arbiter of good food and fashion, and mecca for relaxation, Paris has no rivals. The flower markets, the Louvre, the Eiffel Tower, Opera House, Notre Dame, Les Champs-Elysees, a guided tour of all the famous places in Paris, with some historic information interspersed, this is a film of interest to all ages.

SPACE, Bailey 10 minutes, sound, color. The method of drawing with one and two point perspective is explained carefully. Space by color, by overlapping and by exaggeration are illustrated. Size differences of trees, rabbits, etc., in space are shown. This is a clever teaching film, narrated by William Overhauser.

*LOU GEHRIG'S GREATEST DAY, Young America, 27 minutes, sound. A CBS television production in the "You Are There" series. Walter Cronkite reports on July 4, 1939, the day Lou Gehrig was honored at the close of his great career, sixteen years as the beloved "Iron Horse" of baseball. This film is

a eulogy to the greatness of Lou Gehrig as a man, a tribute to his courage as he faces an incurable illness. Early newsreels show Lou, the hitting demon, in his prime. On the field to honor Lou on July 4 were Mayor LaGuardia, Babe Ruth, and other prominent persons.

*WOODROW WILSON: SPOKESMAN FOR TOMORROW, McGraw-Hill, 27 minutes, sound. Made up entirely of newsreel shots and reproductions of documents and cartoons, this new film follows Wilson as President of Princeton University, Governor of New Jersey, and President of the United States. His great reform laws are recounted. His passionate fight for a League of Nations is covered dramatically, with excerpts from his speeches. The Second World War proved the truth of his warning prediction, and today the fragments of his hope have been re-assembled in the United Nations. Educator, reformer, statesman, spokesman for tomorrow, Woodrow Wilson was one of the true heroes of history.

INDIA'S HISTORY: EARLY CIVILIZATIONS, Coronet, 11 minutes, sound, color. Surveys the early days of India's long and complex history, the original inhabitants, invasions, and the rise of great leaders—Buddha, Chandragupta, and Asoka. Cultural contributions, notably Buddism and Hinduism, made by successive peoples are seen to have their origins in early India.

INDIA'S HISTORY: MOGUL EMPIRE TO EUROPEAN COLONIZATION, Coronet, 11 minutes, sound, color. Beginning with the rule of the Delhi Sultans in the 13th Century, the film traces the growth of the subsequent powerful and enlightened empire of the Moguls, the decline of these rulers, the rise of European interest in India, and the conflict between Britain and France for control of Indian trade, culminating with the Battle of Plassey in 1760.

INDIA'S HISTORY: BRITISH COLONY TO INDEPENDENCE, Coronet, 11 minutes, sound, color. This film examines the centuries during which India's people strove for independence, the realization of independence, and the creation of Pakistan and the Union of India. Also it presents the influence of Mohandas Gandhi and some of the problems facing India today.

*HELEN KELLER IN HER STORY, Contemporary Films, for Louis de Rochemont, 45 minutes, sound. Beautifully narrated by Katherine Cornell, this film tells the story of the little blind-deaf girl who took her place as one of the great personalities of her time. Early sequences must be told through old snapshots and clippings, and the middle period through excerpts from newsreels. But the whole story is set in the framework of Miss Keller's life today—her home, her friends, and her life of service to the handicapped. This is a portrait of a vibrant woman fully enjoying an exciting life, Miss Keller as a "film star" playing herself is exciting to watch. The story of her relationship with her teacher, Annie Sutherland, and her present friendship with her companion, Polly Thompson, is demonstrated movingly. Miss Keller's exploration of the world of nature and the world of music and dance are among the most impressive sequences of a remarkable film.

* Write to the Bureau of Audio-Visual Education, University of North Carolina, Chapel Hill, North Carolina, for booking information.